ORIGINAL

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
	)	
Advanced Television Systems	)	
and Their Impact Upon the	)	**MM Docket No. 87-268**
Existing Television Broadcast	)	
Service	)	
Fifth Further Notice of	)	
Proposed Rule Making	)	

REPLY COMMENTS OF DOLBY LABORATORIES

Aug. 12, 1996

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I. Introduction

Dolby Laboratories ("Dolby") respectfully submits these reply comments on the Commission's Fifth Further Notice of Proposed Rule Making ("NPRM") in its Advanced Television ("ATV") proceeding. We have examined the comments filed in this rule making and wish to address the issues of:

- audio coding systems
- multiple downloadable algorithms
- benefits of a single audio coding standard
- interlace/progressive scan
- square pixels
- aspect ratio
- all format decoding vs. a layered system
- comparison to DBS deployment and the AM Stereo debacle

II. Summary of Reply Comments

Dolby has examined each comment and criticism of the ATSC AC-3 audio coding system offered by DTS/MCA and finds them entirely without merit. On the contrary:

- AC-3 is a widely recognized and growing standard which is not obsolete
- DTS has not demonstrated superiority and DTS technology is not an accepted standard in any consumer format
- DTS' multiple-audio-decoding-system proposal would burden products with unnecessary cost and complexity and would not provide the flexibility they seek
- AC-3 will facilitate the convergence of PCs and TVs
- DTS misrepresented the performance of AC-3 with their test disk

Dolby has examined the comments and criticisms offered by some from the computer, film, and cable industries and finds many of them without merit. Specifically:

- Allowing interlace transmissions will not prevent a move towards progressive scan since the existing interlaced NTSC signals will be with us for many years and progressive displays must allow users to view these interlaced signals;
- The transmission of non-square pixels does not prevent compatibility with computers since, where necessary, pixel shapes can easily be converted by a resampling/filtering process;
- The 16:9 picture aspect ratio is a suitable compromise, and its abandonment would leave the U.S. isolated in the world with a unique aspect ratio;
- The matter of downconversion of a transmitted wide screen picture to a 4:3 display needs attention from the ATSC Implementation Subgroup;
- A layered video coding system would reduce spectrum efficiency and is not necessary for low cost receivers to become widely available;
- The early success of the DBS industry does not imply that terrestrial DTV would not become another AM Stereo debacle if the Commission fails to mandate the ATSC DTV Standard

Opponents have not met the burden of persuasion, but have only raised issues which have already received careful consideration in an open process.

III. Audio Coding Systems

Comments filed by Digital Theater Systems (DTS) and Universal City Studios (MCA) request that the FCC not exclusively adopt the ATSC Digital Audio Compression Standard (AC-3). We understand that MCA (along with several other film industry individuals and organizations) owns equity in DTS, and we suggest that these two sets of comments should be considered as one.

The DTS/MCA comments suggest that AC-3 is already technically obsolete and that a newer DTS audio coding system has been shown to exceed the capability of AC-3. Dolby constantly monitors the development of competing technologies, and we are unaware of any such showing. The "evidence" quoted by DTS is merely a newspaper article. The writer compares a DTS audio system operating at a bit rate of 1,411.2 kbits/sec to his *recollection* of an AC-3 system operating at a bit rate of 384.0 kbits/sec (nearly a 4:1 ratio in bit rate). The writer's lack of scientific expertise is obvious when he draws conclusions about the relative quality of the DTS and AC-3 coding systems without having compared them at the same time and under the same listening conditions using identical program material.

As part of its standardization and international acceptance, the AC-3 coding technology has been evaluated by numerous organizations. Formal tests have been conducted by the Grand Alliance, MPEG, the Japanese BTA, and ACATS. AC-3 has been voluntarily adopted by several of the original ATV proponents, the Grand Alliance, and the laserdisc and DVD industries, and is additionally being used for cable and satellite delivered programming. International acceptance of AC-3 is clearly evidenced by its inclusion in ITU-R Recommendation BS.1196-1, and the DAVIC v1.2 specification. We are not aware of the DTS system being designed into any new consumer delivery format even though it has been heavily promoted for the last couple of years.

The DTS comments claim that the DTS coding system is capable of providing all of the services and features required by the ATV system, including such features as level and dynamic range control. In our study of the limited available information about the DTS coding system, Dolby cannot find any description of how the features required for ATV are provided.

The DTS/MCA comments claim there is no commercial advantage in having a single audio coding standard, and cite as evidence the existence of one DSP IC from Motorola which can decode both DTS and AC-3 audio. While it is clear that it is technically possible for general purpose DSP circuits to decode multiple algorithms, it is also clear to experts in the field that customizing an IC to a particular algorithm leads to a much more cost effective solution. While there is one general purpose DSP chip in the market which can be programmed to decode DTS, Dolby has already issued over 50 licenses for dedicated AC-3 decoder implementations.[1] A substantial

[1] Five of these designs are completed and approved; approximately 15 more are substantially complete.

amount of engineering effort, worldwide, is being expended to bring low cost AC-3 decoders to market. This is a clear indication of the benefit of a standard.

The DTS/MCA comments claim that DTS is superior to AC-3 because it can operate at higher bit rates. There is no fundamental limit to the bit rate at which AC-3 can operate. Bit rates as high as 640 kb/sec are included in the ATSC A/52 standard. For application to ATV broadcasting, the bit rate was intentionally constrained to 384 kb/sec by the Grand Alliance. Dolby would have no objection to raising the allowed bit rate to the 448 kb/sec maximum chosen for DVD applications, or even higher, but cautions that this would lead to small incremental costs in receivers (due to larger memory buffers being required). Dolby does not believe that broadcasters would choose to use higher bit rates for audio coding.

The DTS comments claim that adoption of AC-3 "will place a wall between the merging of Personal Computers and television." The fact that AC-3 is currently being designed into the forthcoming generation of PCs with DVD-ROM storage devices and for Internet, cable modem, and satellite audio delivery, directly contradicts this claim.

The DTS comments claim that adoption of AC-3 would "deter further technical innovations in the field of audio coding." This statement is untrue. The AC-3 encoder is not standardized. The AC-3 syntax and method of decoding the syntax is standardized. The AC-3 encoder is responsible for generating the syntax. AC-3 encoding technology can be improved. Current AC-3 encoders do not fully exploit the available syntax. Dolby is currently making a number of encoding improvements, and we anticipate that the process of improving AC-3 encoding will continue for many years. All AC-3 decoders will benefit from these encoding improvements.

DTS claims that the "Sound quality evaluation disk" which they produced shows that DTS audio coding is more efficient than AC-3. Dolby strongly disagrees with this conclusion (as well as other conclusions drawn by DTS from their own testing[2]). DTS did not use the version of the AC-3 encoder which was used in the ACATS tests, but rather used an implementation embodied in a very early commercial product. Also, DTS intentionally disabled one of the bit rate saving features (coupling) of AC-3 in their tests.

DTS claims that "None of the FCC audio sound quality tests used in-line real-time audio coding-decoding hardware, which is of critical importance for live broadcast applications." This statement indicates DTS' ignorance of the entire ACATS testing process. Like the video coding system, the ATV audio coding system was tested as a complete *hardware* system. The tested hardware included audio encoding, transport encoding, modulation, transmission through a simulated RF

[2] One erroneous conclusion drawn by DTS (and widely publicized by them) was that AC-3 had phase dispersion. In fact, DTS misinterpreted a linear phase vs. frequency plot they had generated. The correct interpretation was that the time delay of the coder had not been exactly compensated for so the indicated phase shift was rising linearly with frequency. There is nothing about AC-3 which would produce phase dispersion.

channel (provided by the test bed at the Advanced Television Test Center), demodulation, transport decoding, and finally, audio decoding. Other applications of AC-3, such as laserdisc and DVD mastering also use real-time AC-3 encoding and decoding hardware.

DTS claims their coding algorithm was designed to faithfully reproduce both film and music based programs. The AC-3 algorithm was also designed to faithfully reproduce both film and music based programs. Most of the AC-3 development taking place at Dolby is done with music based programs for the simple reason that we have musical test sequences of greater criticality.

DTS suggests that broadcasters need to be made aware of problems which may occur with tandem coding. Dolby agrees that tandem coding is a concern and we would like to point out that at the request of broadcasters, AC-3 was tested in a tandem configuration at the ATTC. The test results of the tandem configuration show that no significant degradation was perceived.

The comments of DTS request that "unique descriptors and headers be specified within the MPEG-2 transport to facilitate the transmission of alternate audio and video bit-streams." The MPEG-2 systems layer allows the inclusion of additional bit streams of any type and provides means to uniquely identify them. No action by the FCC or ATSC is required to provide this capability.

IV. Multiple Downloadable Algorithms

DTS appears to suggest that some sort of audio decoding circuitry be standardized without standardizing the audio coding algorithm itself. The actual decoding algorithm would be downloaded during the broadcast. This possibility was discussed and rejected during the deliberations of the ATSC Specialist Group on Digital Services (T3/S3) chaired by Mr. Graham Stubbs.

The primary reason for rejecting this approach was cost. A general purpose audio decoder would cost significantly more than a decoder dedicated to a specific algorithm. To be useful, the general purpose DSP decoder would have to be very precisely specified so that an algorithm designer would know what resources were available. In order to be flexible, the decoder would have to have enough memory, precision, and computational power to decode a wide variety of algorithms. The decoder cost would clearly not be optimized for any particular algorithm, with the result that ATV receiver prices would be unnecessarily raised. The added cost to consumers could easily amount to hundreds of millions of dollars annually.

The AC-3 algorithm was carefully designed to minimize both the amount of computation requiring high precision arithmetic operations (which need long word length arithmetic logic and memory) and the size of memory buffers (the most costly portion of a dedicated IC decoder). These design features make it possible to design very efficient AC-3 IC decoders and will help minimize the cost of ATV receivers and set-top box adapters.

The ATSC T3/S3 group realized that there are practical problems with the concept of downloading algorithm code over the broadcast channel.[3] In a broadcast application, the receiver might be confronted with a new algorithm upon a channel change. The sound would then go silent until the new algorithm was downloaded. This is clearly unacceptable unless the download is very fast. If the download is fast, then significant amounts of transmission bandwidth would be required to repeatedly send the same information which is clearly not an efficient use of spectrum.

Another concern regarding downloading algorithm code is that there is currently no generally accepted method of describing a decoder algorithm, other than as "C" language source code. In the T3/S3 deliberations television manufacturers expressed strong resistance to the concept of including a "C" compiler in every receiver in order to compile source code describing new algorithms into object code suitable for the particular DSP circuitry resident in the receiver. If a particular DSP instruction set were chosen for standardization, then executable object code could be downloaded and the "C" compiler would not be needed. In that case, the ATV standards setting process would turn from a debate over audio coding systems into a debate over DSP architectures and instruction sets (e.g., which of the Motorola DSP56xxx, Zoran ZR38xxx, T.I. DSP320C4x, etc. architectures or instruction sets should be included in the standard?). The intent of the ATV proceeding is to bring high quality pictures and sound to consumers -- not standardized DSP circuitry.

Another questionable issue is that of patent licensing for downloadable algorithms. The considerable R&D expenditures to develop coding algorithms must be offset by income from licensing the resulting patents. When a decoding algorithm is embedded into a receiver, a small royalty on the receiver is a practical means to compensate the algorithm developer.[4] In the case of a downloadable algorithm, this mechanism would no longer work (although it might be used to compensate the developer of the standardized hardware decoder). It would be necessary for the coding algorithm developer to charge the broadcaster for use of the coding system. It is Dolby's experience that content providers do not appreciate being charged a continuing royalty for the use of equipment which they have purchased.[5] We expect

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[3] Dolby does in fact, make use of this technique in our digital sound system for the cinema. In the cinema application the technique is viable because the entire system is designed and controlled by one company, and cost considerations are not as significant. The economics of the cinema marketplace are such that it is acceptable for the audio decoder in a professional cinema product to be implemented less efficiently, and for large amounts of non-volatile RAM to be provided for storage of alternative algorithms. When a new algorithm is delivered on a new film release print, it is acceptable for the digital sound to go silent for a minute while the new algorithm is downloaded. (This would typically occur during a test run prior to the showing of a new film to an audience; if there is no test run, and a new film containing a new audio coding algorithm is put up for the first time in front of an audience, the cinema decoder would revert to the analog soundtrack until the download of the new code is complete.)

[4] This mechanism has worked quite well in the case of the "Dolby B" noise reduction system which has been implemented in approximately 500,000,000 cassette decks

[5] In the case of Dolby B, as well as all other Dolby technologies, Dolby does not charge any per unit royalty for each cassette tape, digital film, DVD, etc. produced using the technology. This is in contrast to

that broadcasters would strongly resist payment of ongoing royalties in return for the ability to continue to broadcast DTV signals which include audio content.

V. Benefits of an Audio Coding Standard

There are many benefits to the selection of a single audio coding standard. A standard gives manufacturers a certainty as to what to build Free market competition will drive implementation cost down, leading to lower priced receiving equipment (a principle tenet of the Telecommunications Act of 1996). For example, manufacturers of NTSC TVs have competed fiercely in the market for decades, continually adopting new technologies, securing lower prices and delivering higher audio and video quality to consumers, all without vacating the original NTSC audio and video standards.

The certainty that an audio coding algorithm will be widely used encourages use of the algorithm for other applications and helps drive interoperability. In the case of audio coding, the cost, performance and efficiency of AC-3, as well as the near certainty that it will be adopted for broadcasting in the U.S., has strengthened already established support for adoption of AC-3 in other applications.[6] Early adoption has led to development of consumer "home theater" products incorporating AC-3 decoders. These products are already in stores and consumer homes (> 50,000 as of June '96). A failure to adopt the ATSC DTV standard and to begin broadcasting AC-3 audio could cause a significant disruption in this rapidly developing marketplace.

Anyone can argue that any standard is obsolete. Technically this may be true since it takes several years for the standardization process and marketplace introduction to occur and, given a few more years of development, incremental improvements can generally be made to any algorithm. This reality should not freeze us into inaction. A broadcast standard is not necessarily valued based on its immunity to technical or theoretical obsolescence. Virtually every broadcast standard in use today may be described as obsolete on this superficial basis, almost from inception. The overriding issue is that a standard fosters wide acceptance and broad benefits to society.

VI. Interlace/Progressive Scan

Dolby notes with some dismay and disbelief the comments claiming ruinous effects on our society if broadcasters are allowed to select an interlace mode of transmission for some programs. Some of those commenting seem to want the Commission to outlaw any use of interlaced video, and any manufacture of interlaced displays (it is not clear if they intend the government to seize and destroy all existing

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DTS approach of charging per-unit for each copy of a film soundtrack made available in the DTS digital cinema system.

[6] Other media which have adopted AC-3 include: broadcast media such as cable and satellite delivery; packaged media such as laserdisc and DVD movies; and computer media such as DVD-ROM and the Internet.

interlaced tapes, etc.). While we see much merit in the arguments for the superiority of progressive scan, we also appreciate the reality that interlace NTSC will not disappear from our lives for many years. During this lengthy transition to progressive scan (which will certainly be driven by free market forces if the benefits touted for progressive scanning are real), any progressively scanned displays will need the capability to display pictures received from interlace scan sources (NTSC transmissions, VHS tapes, laserdiscs, consumer VHS or 8mm camcorders, DVDs, MPEG-2 on cable and satellite, etc.). Certainly any computer which becomes part of a home entertainment system will need to display interlace signals for at least the next 10-20 years (after which the cost of a deinterlacer will surely have become negligible) Given that nearly all displays will need the capability to display interlaced signals, we can see no substantial benefit in removing the interlace modes from the ATSC DTV Standard.

Our experience in the ATV standards setting process leads us to believe that the remarkable consensus which has been achieved would be in jeopardy if the FCC were to attempt to redesign the ATSC DTV system based on a few negative comments on some aspects of the system. While removal of interlace formats might make the DTV system somewhat more *computer friendly*, it would become less *broadcast and video friendly*. Certainly it is reasonable to expect a *broadcast* system to give at least a slight preference to the wishes of the *broadcast* industry

VII. Square Pixels

Dolby also notes with dismay and disbelief the comments claiming that the non-square pixel formats prevent interoperability with computers. In our own laboratory one of the most popular display modes in use on our computers is 1280 by 1024, which does not produce square pixels on our 4x3 displays. The lack of square pixels on our computer displays has not caused us any problems.

If a particular display requires square pixels they can easily be created by resampling/filtering the horizontal video information This is analogous to sample rate conversion for audio signals. While converting the sample rate of audio signals was once a very expensive and onerous task, it is now considered a relatively minor task. We would like to point out that this issue was fully discussed and considered during the deliberations of the ATSC Technology Group on Distribution (T3). The need for some displays to resample the contents of video lines, while clearly a nuisance, is not so burdensome that the approval of the ATSC DTV Standard should be withheld.

VIII. Aspect Ratio

Dolby respectfully disagrees with the vocal contingent from the film industry who claim that a 2:1 aspect ratio is essential to accommodate film programs. The choice of an aspect ratio is, of course, a compromise. There are many benefits to having a worldwide agreement on aspect ratio The 4:3 aspect ratio has been used all

over the world and its universal use has facilitated interoperability worldwide. Currently, we have worldwide agreement on the 16:9 aspect ratio (which was chosen approximately 10 years ago in careful due process deliberations held in Hollywood). Dolby's experience in the area of international standards activities allows us to confidently state that this worldwide agreement on aspect ratios is quite remarkable. If the U.S. were to change aspect ratios at this point in time, we are confident that the rest of the world would not follow suit. This would leave the U.S. in an undesirably unique position and could cause significant damage to our production and distribution industries, raise consumer prices, and negatively affect the export of widescreen programming.

We agree that a 2:1 aspect ratio would be preferable for 2.35:1 films, but it would be worse for 1.85:1 films, or 4:3 films and video productions. The 16:9 value is a very reasonable compromise (which is why it was chosen in the first place). If filmmakers wish to assure that their 2.35:1 widescreen films are broadcast with their full width intact (letterboxed rather than horizontally cropped i.e., all 12 disciples visible in *The Last Supper*), they should include such a requirement in the license agreement which gives the broadcaster permission to transmit the film. This can be a free market transaction without government intervention.

We are aware of one item concerning aspect ratio which has not received adequate consideration, and that is, how the downconversion of the transmitted widescreen 16:9 image to a 4:3 display will occur. If an image has been accommodated by the 16:9 aspect ratio, but a downconversion is performed by a set-top adapter feeding an existing 4:3 display, the image is likely to be horizontally cropped. This cropping of the 16:9 image to fit on the 4:3 display may be artistically unacceptable. It is technically possible for the downconversion to the 4:3 display to be done by shrinking and letterboxing the 16:9 image instead of cropping it. Note that this is a receiver/display issue, and not a transmission format issue. However, the transmission could (and perhaps should) convey information intended to instruct the downconverter as to which type of aspect ratio conversion to perform (cropping with pan and scan, or shrinking with letterboxing). We suggest that this issue should be addressed by the ATSC Implementation Subgroup.

IX. All Format Decoding vs. a Layered System

A number of comments claim that consumers will be forced to pay high prices for ATSC DTV receivers because all receivers will have to decode the full HDTV quality signal. These comments (the $91 billion misinformation campaign) suggest that instead, the DTV system should be layered, where a low resolution base layer is transmitted along with an optional HDTV enhancement layer. We disagree with these comments.

Layered coding systems are not as efficient as single layer systems. Within the constraints of the 19 Mb/s data rate of the 6 MHz channel, we believe that the picture

quality of a single layer coding system will exceed that of a multiple layered coding system. While the lower efficiency of the layered system may be acceptable for other wired media (cable, telco, computers), it is not acceptable for a broadcast system using scarce and valuable spectrum.

It is true that the cost for a base layer decoder would be lower than that of a full HDTV decoder, but the magnitude of this cost difference has been greatly exaggerated in many comments. We believe that all-format decoders will become available which will be capable of decoding all of the HDTV resolution formats with only a small incremental cost over that of a decoder which could only decode the base layer of a layered system. A layered system would provide a small short-term cost advantage, but would impose a long lasting penalty upon the spectrum efficiency of the DTV system.

X. Comparison to DBS and the AM Stereo Debacle

Comments filed by the NCTA point out the success of the DBS industry in applying digital broadcasting without a government mandated standard. The NCTA argues that this example shows that the FCC does not need to set a broadcast standard for DTV to become a commercial success. Others have reminded the Commission of the AM Stereo debacle where the FCC did not dictate a standard.

Dolby would like to point out that even though DBS has been remarkably successful (reaching a market penetration of a few percent in a few years), terrestrial DTV will have to be much more successful if the NTSC spectrum is to be recovered in the hoped for 15 year time span. The current success of DBS is in spite of, not because of, lack of a standard for DBS broadcasting.[7] While all of the current and proposed DBS systems are quite similar, they are all sufficiently different that consumers must purchase a different DBS receiver for each service they wish to receive. This has not yet become an issue which constrains the expansion of the DBS industry, since each of the DBS service providers are transmitting many of the same identical program services (which is not a particularly efficient use of the DBS spectrum, and certainly a situation which should not occur with terrestrial DTV). We are, however, beginning to see consumer dissatisfaction that equipment purchased to receive one service cannot receive other services. While some in the cable industry may think this kind of situation is satisfactory, we do not.[8]

Absent an FCC mandated ATSC DTV Standard, terrestrial DTV could become another debacle like AM Stereo. The comments filed in this proceeding contain many

[7] It is widely reported that much of the success of DBS is due to consumer dissatisfaction with the cable industry.

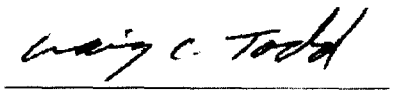
[8] Since DBS services are typically national in coverage, consumers who purchase equipment in one part of the U.S. are able to move to another location in the U.S. and still receive that one particular service. Like DBS, the cable industry also uses many non-standard incompatible technologies. If consumers owned certain types of cable decoding equipment, in many cases they would not be able to move into the next town and still be able to receive service.

suggestions for modifications to the ATSC DTV Standard. Absent a Commission mandated standard, many of these ideas may be implemented in systems brought to market to compete with the ATSC DTV system If so, consumer confusion would be substantial and this confusion would lead consumers to avoid purchasing DTV receivers until the technology sorted itself out. As taught by the AM Stereo lesson, once the situation was sorted out ultimately by imposition of a mandated standard, the opportunity had been lost. AM Stereo languishes to this day. The Commission must take decisive and timely action to sanction the ATSC DTV Standard. The NTSC spectrum is too valuable to put its recovery at risk

XI. Conclusion

The Commission was correct in stating that opponents of the system should have the burden of persuasion as to why the ATSC DTV Standard should *not* be adopted. Opponents of the system have only raised issues which have previously been thoroughly studied during the "... years of thoughtful consideration and expert research and development in an open process in which all interests were able to participate"(NPRM, ¶54) The industry has already spent 10 years debating these issues and has achieved a substantial consensus The time for debate has now passed. The Commission must act decisively now by mandating use of the complete ATSC DTV Standard. This critically important leadership action by the Commission will allow industry and consumers to realize the myriad of benefits of such a standard, including the rapid and successful transition from analog to digital terrestrial television.

Respectfully submitted,



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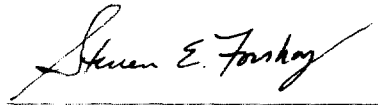

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